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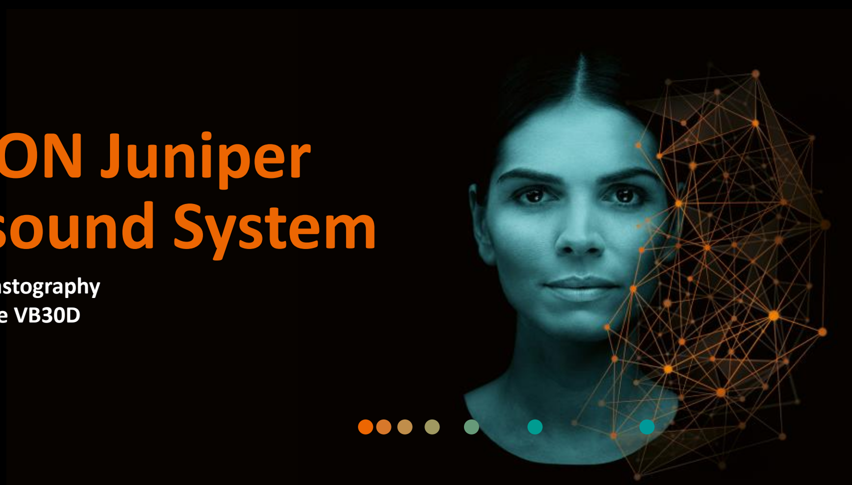
ACUSON Juniper Ultrasound System

Virtual Touch Elastography
Software Release VB30D



Speaker Notes:

In this presentation we will discuss Virtual Touch™ elastography on the ACUSON Juniper ultrasound system.

Objectives

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- Explain Virtual Touch™ technologies
- Demonstrate Strain imaging (eSie Touch™ elasticity imaging)* controls and techniques
- Demonstrate point shear wave elastography (Virtual Touch quantification)* controls and techniques in liver applications

*Note: This presentation uses the term “Strain imaging” to refer to “eSie Touch elasticity imaging” displayed as “eSie Touch” under the “Elasticity” tab on the ultrasound system. It also uses the term “Virtual Touch pSWE” to refer to “Virtual Touch quantification” displayed under the “Elasticity” tab on the ultrasound system.

Speaker Notes:

Here are the objectives for this presentation. We will begin with explaining the Virtual Touch™technologies.

*Note: This presentation uses the term “Strain imaging” to refer to eSie Touch™ elasticity imaging displayed as eSie Touch under the “Elasticity” tab on the ultrasound system. It also uses the term “Virtual Touch pSWE” to refer to “Virtual Touch quantification” displayed under the “Elasticity” tab on the ultrasound system.

The next dimension of diagnostic information

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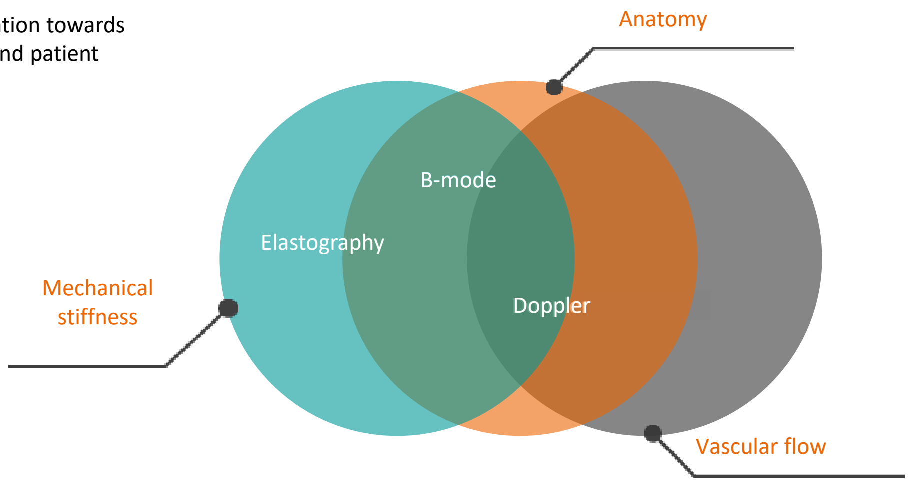
Additional information towards clinical diagnosis and patient care



Speaker Notes:

Elastography provides a new dimension of diagnostic information to the ultrasound exam. With B-mode imaging, a diagnosis is based on the appearance of tissue in levels of gray and the presence of clinical markers, such as shadowing or enhancement. Doppler provides information on the presence or absence, speed and direction of vascular flow. Elastography allows us to assess the mechanical stiffness of tissue, providing additional information towards the clinical diagnosis and care of a patient.

Elastography provides information on tissue stiffness

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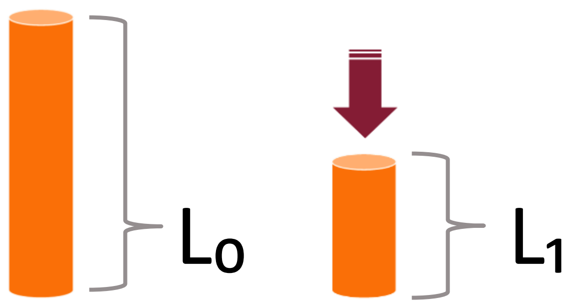
Hooke’s Law:

Stress = Force/Area

Strain = Δ Length/Original Length

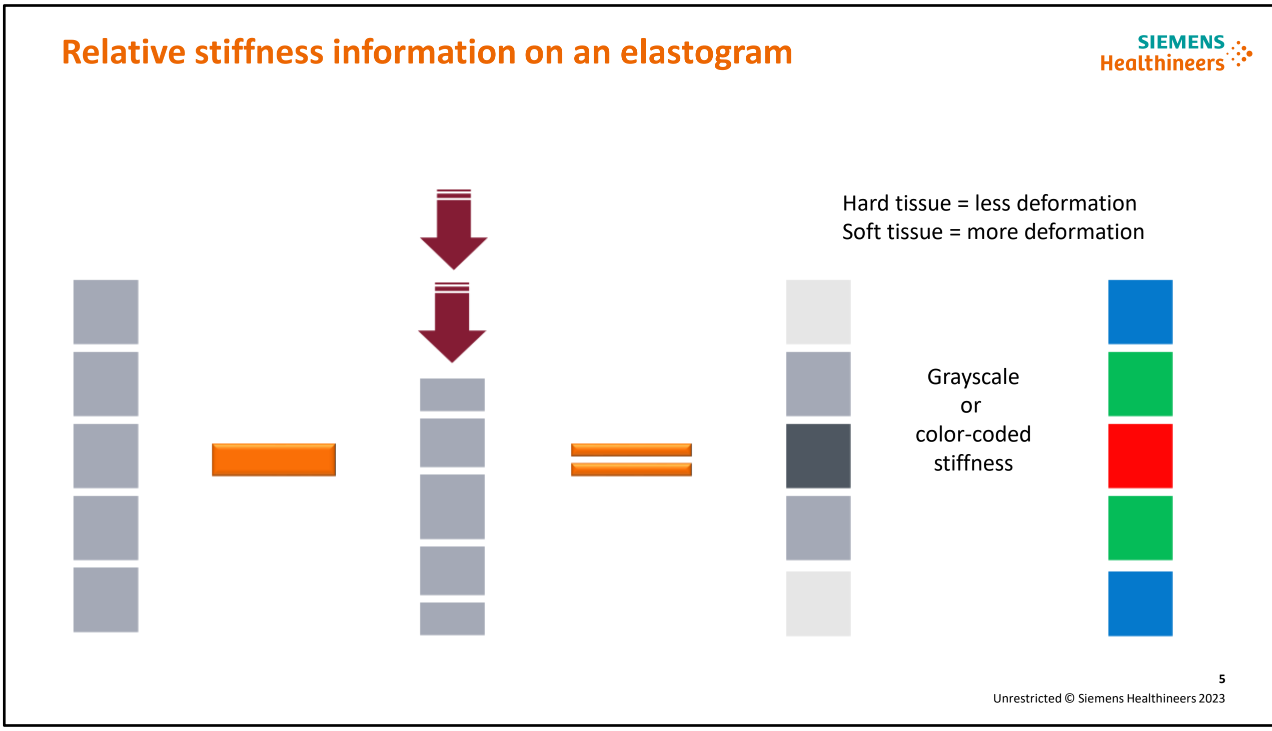


$$\varepsilon = \frac{L_1 - L_0}{L_0}$$

Deformation = relative change in shape or size of tissue after it is stressed

Speaker Notes:

Elastography provides information on tissue stiffness. To obtain this information, the tissue needs to be deformed. Since elastography is based on Hooke’s Law, let’s go over the basic concept of Hooke’s Law. Here we have a structure; let’s say, for example, it’s tissue, with a length of L0. We deform the tissue with an applied force to stress the tissue. Now the tissue has a length of L1. Next, we compare the before and after lengths of the tissue by dividing the change in length from the original length to calculate the strain, or the variation in tissue deformation, which is the relative change in shape or size of the tissue after it is stressed.



Speaker Notes:

Now let's go over how we display the result as an elastogram on ultrasound. Here we have a column of tissue elements that might appear identical on the B-mode image. When a stress is applied, the tissue elements can behave differently. The middle tissue element experiences almost no deformation because it is hard, but the elements at the periphery of the column experience more deformation because they are soft. Using the difference between the original and stressed image, the original image can now be labeled and displayed with stiffness information. We look to the grayscale or color bar that is displayed next to the image, and, by convention, a dark shade is used to indicate stiff or hard tissue and lighter shades are used to indicate softer tissue. If a color map is selected, the color bar indicates which color represents soft or hard tissues. These gray or color shades are then used to assign and display the relative stiffness of tissue on the elastogram.

Methods to deform tissue

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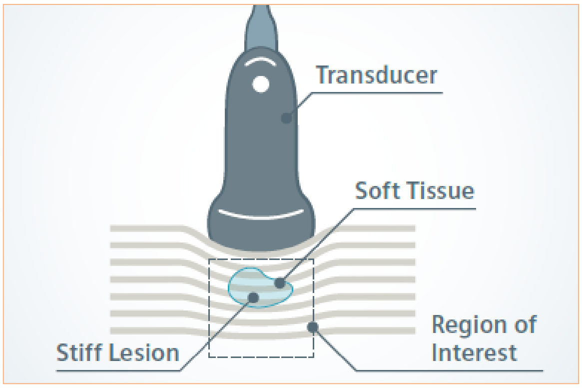
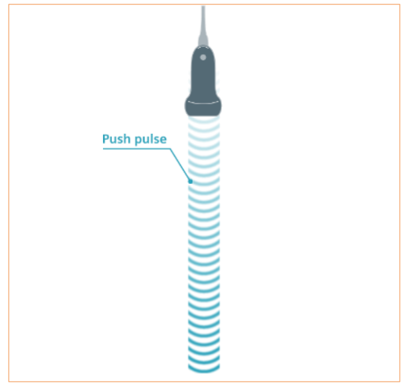


Manual Compression



Acoustic Radiation Force Impulse (ARFI)

Speaker Notes:

Now let's discuss the two methods used to deform the tissue. The manual compression technique has traditionally been described as Strain imaging. Using manual compression, stress is created by the user applying minimal compression with the transducer. With this technique, we can effectively apply stress to superficial structures, but are not always able to generate enough stress to the deeper tissue elements. This challenge led to Acoustic Radiation Force Impulse imaging, or ARFI. ARFI uses a "push pulse" produced by the transducer to deform tissue. Using ARFI, we can now penetrate deeper tissues than we could with the manual compression technique.

Shear waves
Transverse waves generated from the ARFI push pulse

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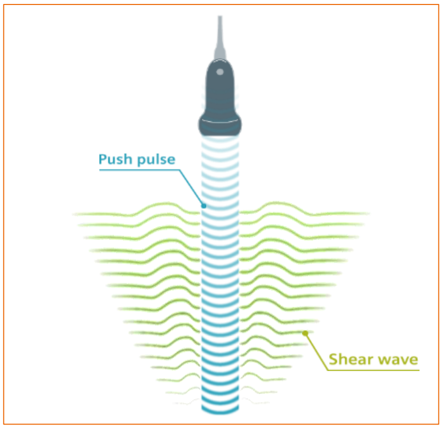
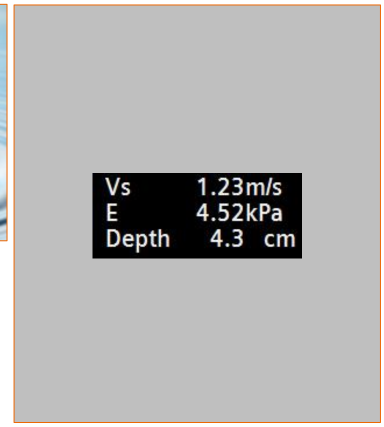
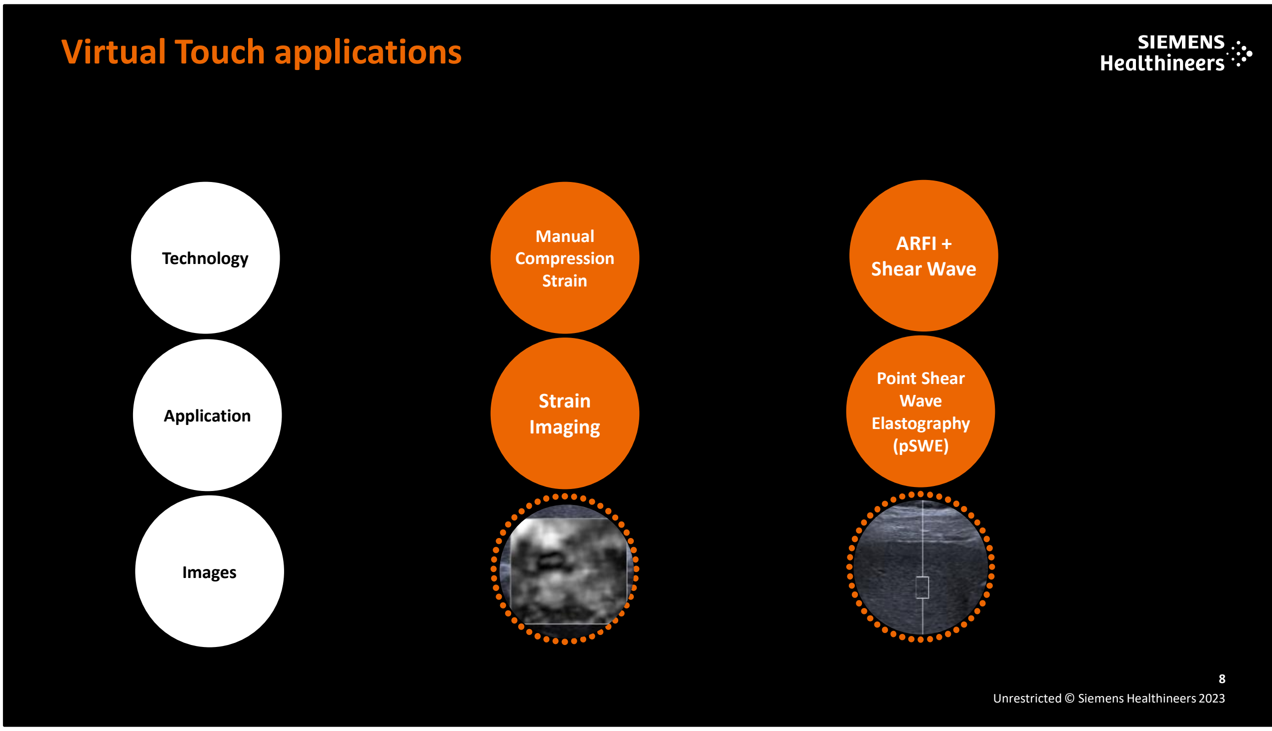


ARFI



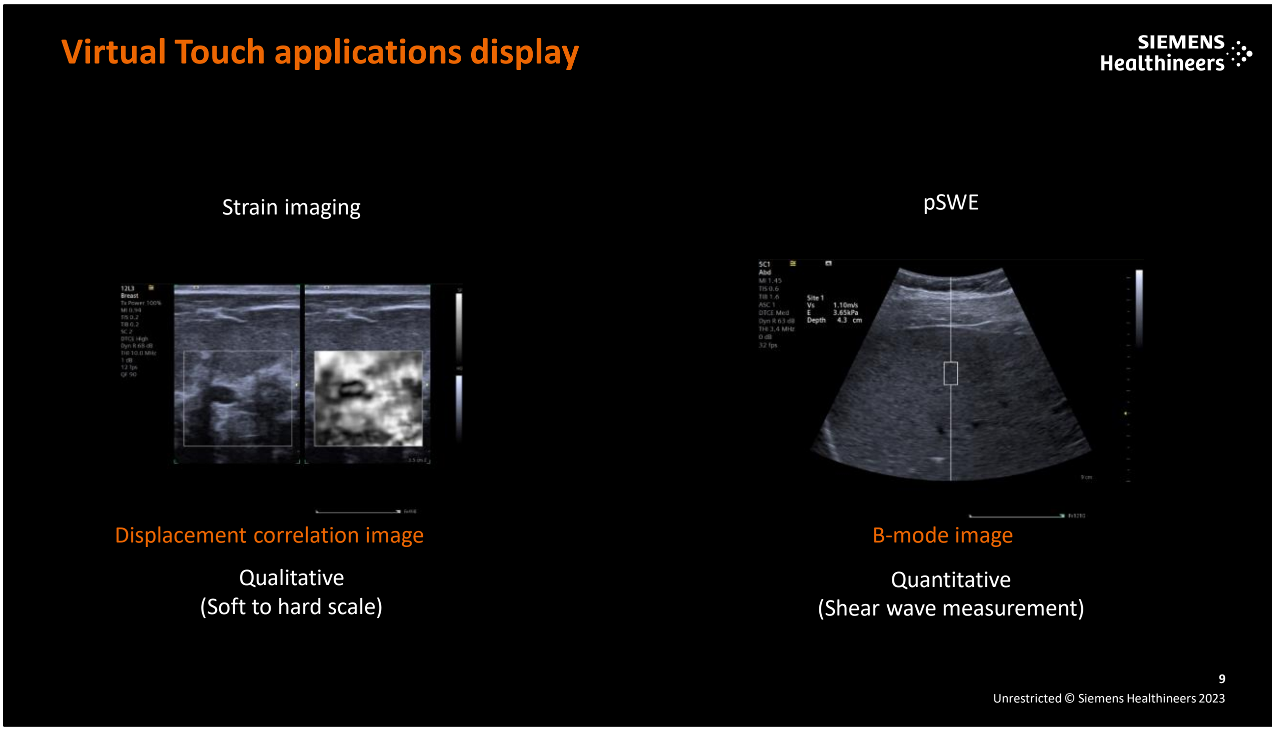
Speaker Notes:

Shear waves are transverse mechanical waves generated from the ARFI push pulse. Shear waves move at different speeds through different kinds of tissue. For example, if a pebble is tossed into a puddle of water and then into a puddle of syrup, the waves created will move at different speeds. Shear waves travel at much slower speeds than longitudinal waves. As an example, shear waves in human soft tissue travel anywhere from 1-10 meters per second (m/s), while longitudinal waves are much faster, at ~1540 m/s. This slower travel time allows us to track and measure the speed of the waves using conventional ultrasound beams for detection. The shear wave speed can be measured to give quantifiable measurements of tissue stiffness, something manual compression elastography alone has never been able to do. Velocity is a measurement in m/s and represents the speed of the shear wave. Kilopascal (kPa) is the measurement unit for elasticity (stiffness), i.e., Young's Modulus of Elasticity. Virtual Touch elastography calculates and displays shear wave measurements in both velocity (m/s) and elasticity (kPa) units next to the image and in the report.



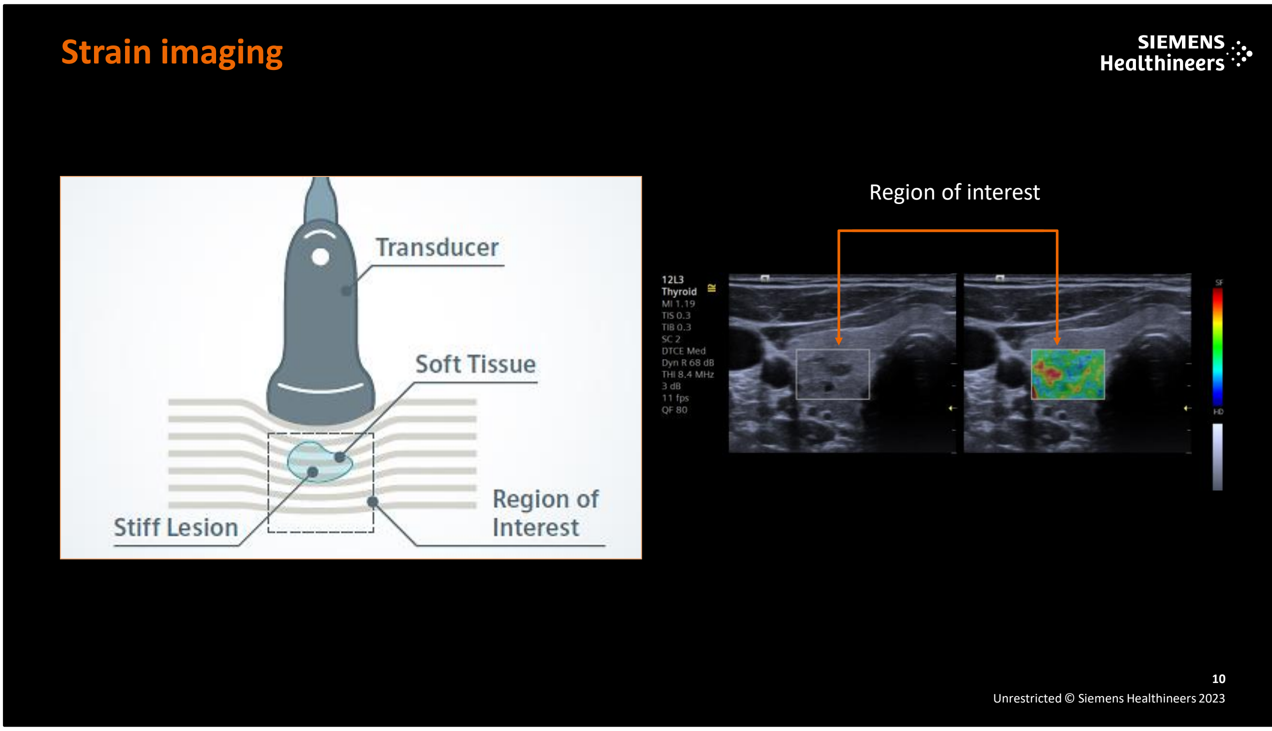
Speaker Notes:

The ACUSON Juniper™ ultrasound system offers both Strain imaging and point shear wave elastography (pSWE) applications. Strain imaging uses manual compression to produce an elastogram image based on displacement of the tissue and relative tissue stiffness. pSWE uses ARFI to deform tissue and quantitative shear wave measurements can be made.



Speaker Notes:

Strain imaging creates a displacement correlation image, mapping relative stiffness, which can be qualitatively assessed. Notice that the gray or color bar next to the strain image indicates hard or soft and has no numerical values. pSWE displays only the B-mode image along with a shear wave measurement in units of m/s and kPa; hence, it can be quantitatively assessed.



Speaker Notes:

Strain imaging provides a visual assessment of tissue stiffness and can, for example, allow a subtle lesion in soft tissue to be more clearly visualized and assessed. When uniform stress is applied, each tissue type will deform differently. The resultant mapping of these different degrees of deformation clearly illustrates relative tissue stiffness. When Strain imaging is activated, the B-mode image will display side-by-side with the elastogram and the region of interest (ROI) box can be resized and repositioned over the desired area. Using real-time correlation methods, the system continuously estimates the degree of tissue deformation and displays the relative stiffness in either a gray scale or colorized elastogram.

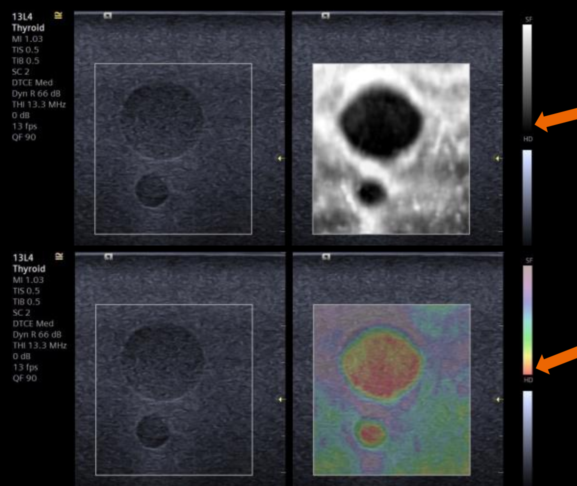
Strain imaging
Relative stiffness

Qualitative gray map

- Stiff lesion
- Darker gray = harder than surrounding tissue

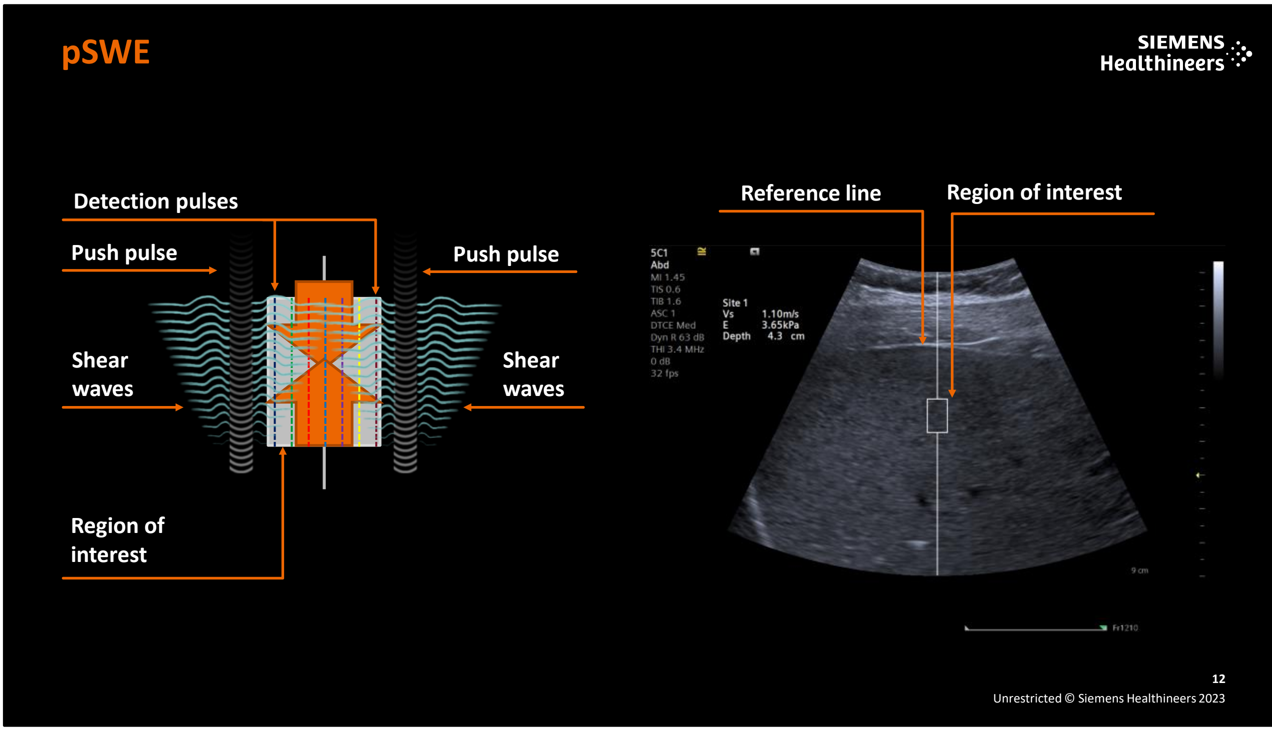
Qualitative color map

- Stiff lesion
- Red = harder than surrounding tissue



Speaker Notes:

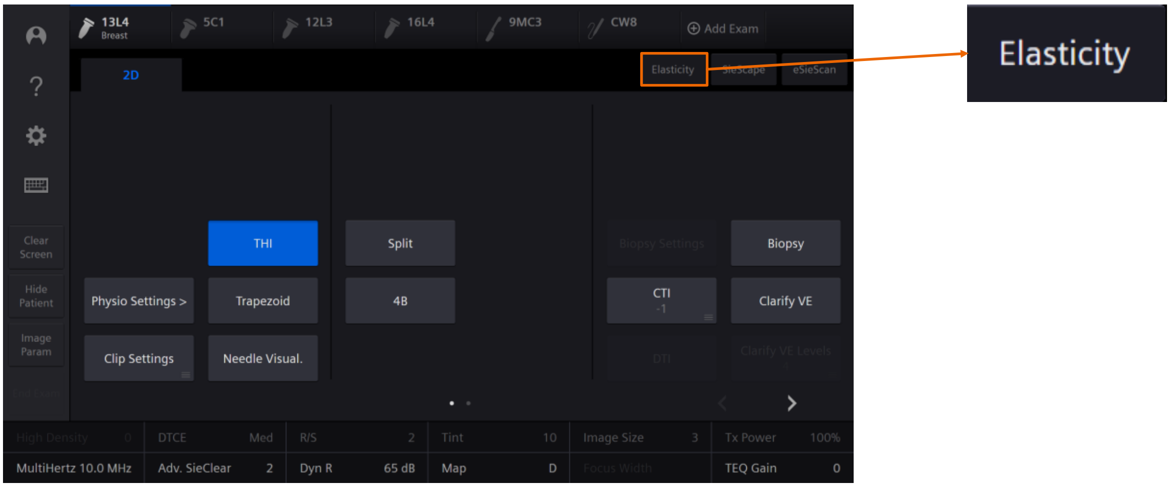
When using Strain imaging, it is important to understand what the gray shades and color shades indicate on the elastogram in terms of “relative stiffness”. The qualitative gray map and color map in these two images indicates that the lesion is stiffer, or harder, relative to the surrounding tissue. As shown in the image on the top, the gray bar located next to the image indicates that tissue displayed in darker gray shades are “harder” while lighter gray shades are “softer”. In the image on the bottom, the color bar located next to the image indicates that tissue displayed in redder colors are “harder” while pinker colors are “softer”.



Speaker Notes:

pSWE applies multiple push pulses on both sides of the ROI producing shear waves that are propagated perpendicular to the push pulse throughout the tissue and in the ROI. Multiple detection pulses are sent through the ROI to monitor the speed of the shear wave. The speed correlates to the tissue stiffness. The quantitative result is instantly displayed next to the image in units of m/s and kPa along with the depth of the ROI.

ACUSON Juniper ultrasound system



Speaker Notes:

To access Virtual Touch elastography mode, select a compatible transducer and exam preset and then select the **Elasticity** tab on the Touch Screen.

Virtual Touch application compatibility matrix

Application	18H5	16L4	14L4	13L4	12L3	11L4	L10-5V	6C1	5C1
Strain imaging	Thyroid	Thyroid & Breast	Thyroid & Breast	Thyroid & Breast	Thyroid & Breast	Thyroid & Breast	Thyroid & Breast		
Point Shear Wave Elastography (pSWE)								ABD	ABD

Speaker Notes:

Elastography is a technique that non-invasively visualizes and measures the change in tissue stiffness, a key characteristic of diseased tissue (that is often stiffer).

The ACUSON Juniper system offers:

- Strain imaging – compatible with five transducers in two exam presets
- Point shear wave elastography (pSWE) – compatible with the 5C1 in the Abdomen preset

Objectives

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- Explain Virtual Touch technologies
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Speaker Notes:

Next, we will discuss the strain imaging controls and techniques.

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Strain imaging

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High sensitivity, but difficulty defining the lesion size (boundaries) in isoelastic benign lesions reduces specificity

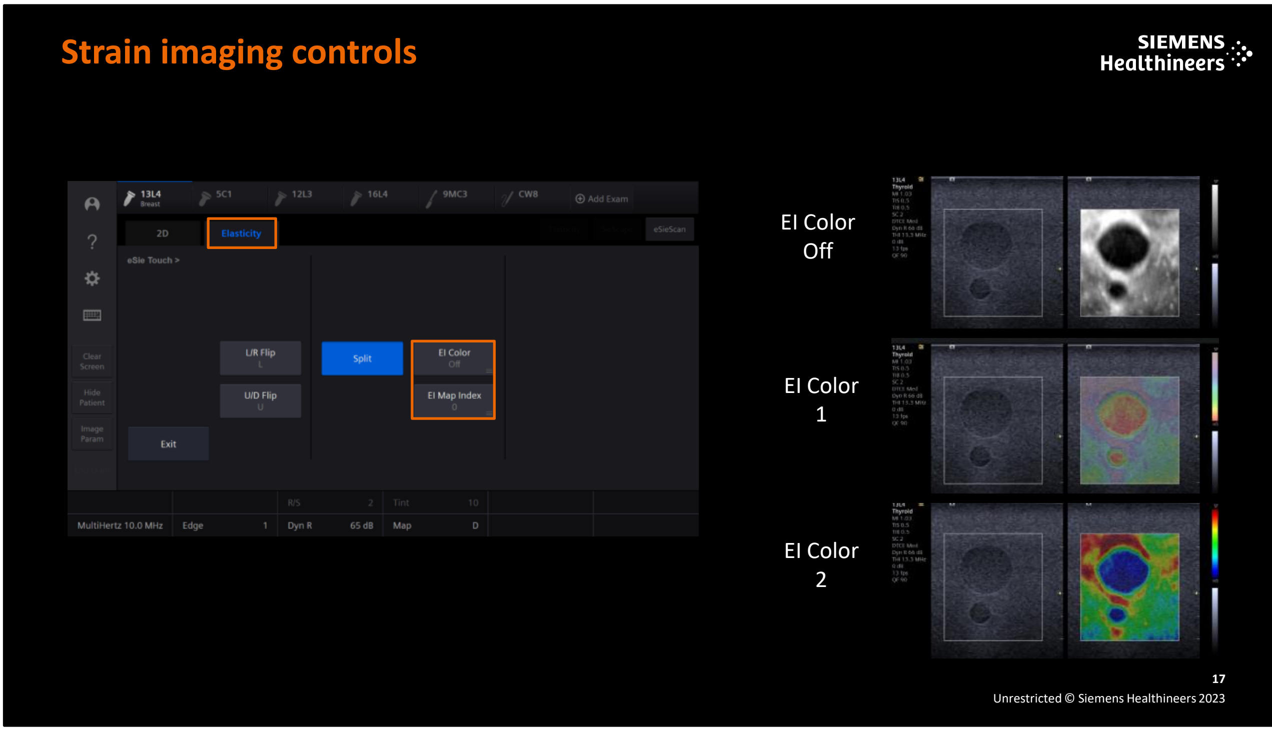
Site	Total Lesion	Malignant Lesions	**EI/B-mode Ratio≥1**	**Sensitivity**	Benign Lesions	**EI/B-mode Ratio<1**	**Specificity**
1	251	54	54	**100%**	197	188	**95.4%**
2	79	40	40	**100%**	39	26	**66.7%**
3	206	90	87	**96.7%**	116	100	**86.2%**
4	52	14	14	**100%**	38	29	**76.3%**
5	34	18	18	**100%**	16	12	**75.0%**
6	13	6	6	**100%**	7	6	**85.7%**
Total	635	222	219	**98.6%**	413	361	**87.4%**

Evaluation of Breast Lesions Using Ultrasound Elasticity Imaging: A Multi-centered Trial

Barr RG, Destounis S, Lackey LB, Svensson WE, Balleyguier C, Smith C. Journal of Ultrasound in Medicine 2012 Feb; 31(2): 281-7

Speaker Notes:

Strain imaging has been widely used in breast and thyroid imaging and is still relevant today as a highly sensitive indicator of relative tissue stiffness in focal lesions. In this multi-center study at six locations around the world, the reproducibility of strain imaging used in breast lesions yielded 97-100% sensitivity in all locations. Specificity was lower, primarily due to the difficulty in defining the lesion size (boundaries) in benign lesions, which are relatively isoelastic when compared to normal breast tissue.



Speaker Notes:

The Virtual Touch elastography mode will display the dedicated elastography applications that are available for the selected transducer and exam preset. Each application has its own dedicated tab folder containing the controls that can be used to perform the application. When Strain imaging is activated, the B-mode image and elastogram display in a split format as shown here. If needed, the region of interest can be resized and repositioned over the area of interest. The image can be zoomed before or after acquisition. A Color map can be selected to display the strain image in vibrant red to vibrant blue shades or in soft pink to soft red shades. Three different Map Index settings are available: 1 = Standard default map, 2 = Normalized map to compensate for non-uniform stress applied with the transducer, and 3 = Inverted map.

Strain imaging techniques

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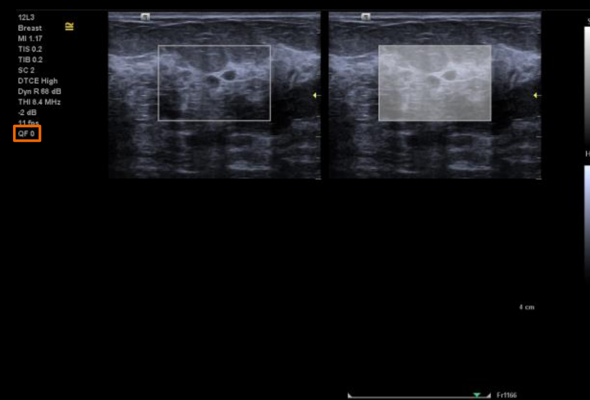
- Position the patient to obtain perpendicular plane to skin
- Minimal compression (use respirations or cardiac motion)
- Avoid lateral or rocking motion
- Quality Factor (QF) > 50
- Optimize elastogram, then Freeze
- Cine to obtain desired frames

Avoid gray overlay box as shown here

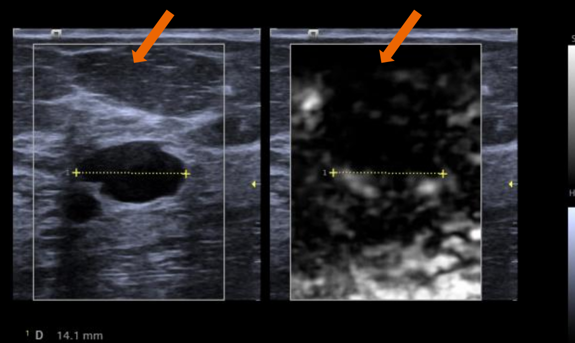


Speaker Notes:

Use best practice techniques when performing Strain imaging for reliable and repeatable results. First, optimize the scan direction by positioning the patient to obtain as much of a perpendicular plane to skin surface for good axial motion. Then, apply minimal compression. The natural compressions generated by a patient's respirations and cardiac motion may be sufficient to generate the elastogram. If a gray overlay is displayed on the elastogram, as seen in this image of a breast lesion, it indicates one of the following conditions: Too much lateral movement or rocking motion, too little pressure or too much pressure, which causes the lesion to slip in and out of the plane. The system also displays a real-time Quality Factor score. Maintain a Quality Factor greater than 50 for optimal results. Optimize the elastogram and then press "Freeze" on the Control Panel. At this point, you would review the cine to obtain desired frames and then choose a frame that contains several consecutive frames with the same Quality Factor score.

Effects of precompression

- Too much pressure substantially changes elastographic results
- Soft tissue can appear hard
- Minimize precompression by using minimal pressure

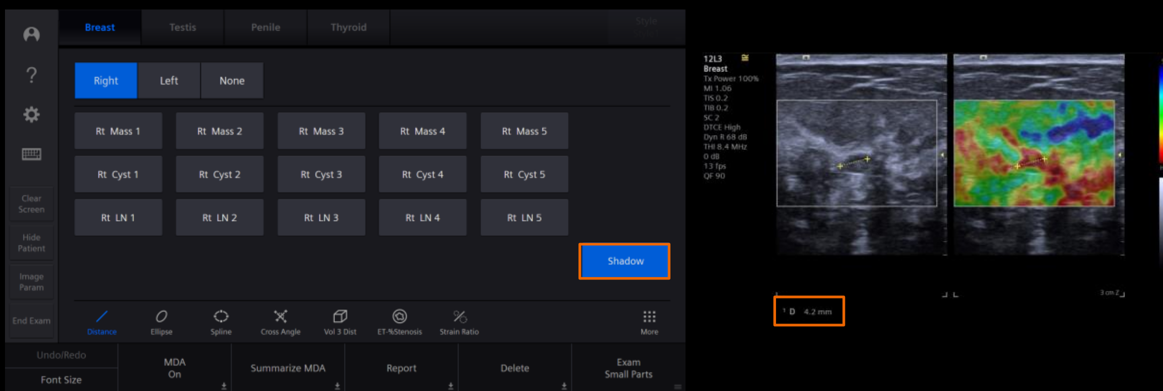


Speaker Notes:

It is important to utilize proper scan technique to minimize the effect of precompression. If too much pressure is applied with the transducer, elastographic results can substantially change. Fat can appear to have the same elasticity as cancer when too much pressure is applied. In this image of a breast cyst, the soft tissue in the near field appears to show an increase in stiffness due to the effect of precompression. Precompression is a substantial factor in obtaining accurate results with elastography. Precompression should be minimized in obtaining clinical images.*

*Barr, R. G. and Zhang, Z. (2012), Effects of Precompression on Elasticity Imaging of the Breast. *Journal of Ultrasound in Medicine*, 31: 895-902. doi:10.7863/jum.2012.31.6.895

Shadow measurement



Speaker Notes:

When the Shadow measurement is active, the system duplicates and displays the measurement on the adjacent image for a comparison of lesion size and/or location. To perform a Shadow measurement, select **Split**, if needed, and then press **Caliper** on the Control Panel to enter the measurement menu. Select **Shadow** on the Touch Screen to activate and measure either image. The measurement displays in the measured results, as shown here in the image of a breast cyst.

Strain ratio measurement

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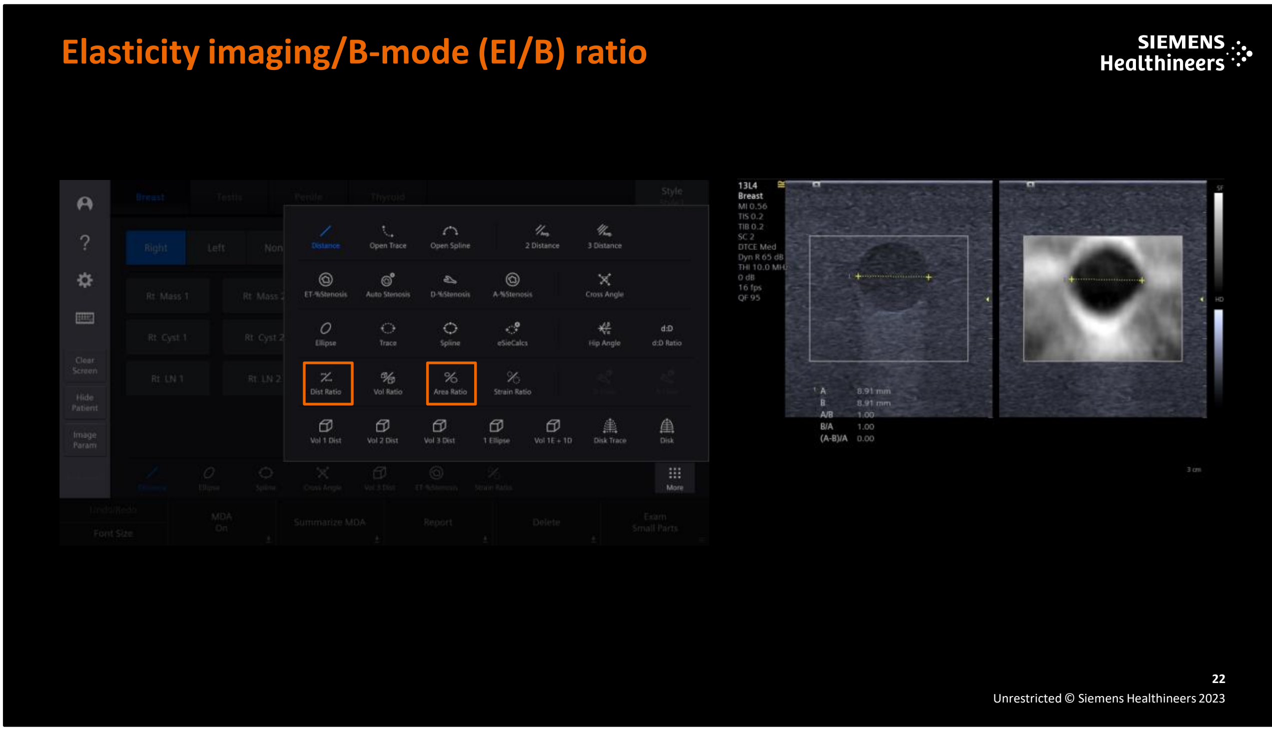
Strain Ratio = ROI 1 (Ref)/ROI 2 (Mass)

- Place ROI 1 (Ref) in tissue
- Place ROI 2 (Mass) in lesion (same size and at same depth)
  - Results: > 1 = Lesion is harder than the surrounding tissue
  - Results: ≤ 1 = Lesion is softer or the same as the surrounding tissue

Speaker Notes:

Strain ratio compares the relative stiffness of tissue within two ROIs. The strain ratio is the result of dividing ROI 1 (Ref) by ROI 2 (Mass). When the first ROI is placed in the surrounding tissue and the second ROI is placed in the lesion, a strain ratio greater than 1 indicates that the lesion is harder than the surrounding tissue. A strain ratio less than or equal to 1 indicates that the lesion is softer or the same as the surrounding tissue. The strain ratio and the average strain percentage for both regions of interest are displayed in the measured results. The strain ratio and average strain (%) for both ROIs are displayed.



Speaker Notes:

One of the most sensitive indicators for the likelihood of breast lesion malignancy is the ratio of the lesion size in the elastogram compared to the lesion size in the B-mode image. Research has shown that suspicious breast lesions appear measurably larger with elasticity imaging versus B-mode imaging. It is hypothesized that this is due to the detection of tentacle formation and/or desmoplasia, which is the growth of fibrous or connective tissue. When the ratio is >1, the probability of malignancy is increased.* In this example, the elasticity imaging to B-mode ratio diameter measurement has been used to compare the size of a lesion visualized in the elastogram with the size of the same lesion visualized in the B-mode image. The ratio of the elastogram measurement divided by the B-mode measurement is displayed as 1.00 in the measured results, indicating that the lesion size is measuring the same in both the elastogram and the B-mode image.

*Barr, R. G., De Silvestri, A. , Scotti, V. , Manzoni, F. , Rebuffi, C. , Capittini, C. and Tinelli, C. (2019), Diagnostic Performance and Accuracy of the 3 Interpreting Methods of Breast Strain Elastography: A Systematic Review and Meta-analysis. *J Ultrasound Med*, 38: 1397-1404. doi:10.1002/jum.14849

“Bull’s-eye” appearance in cysts

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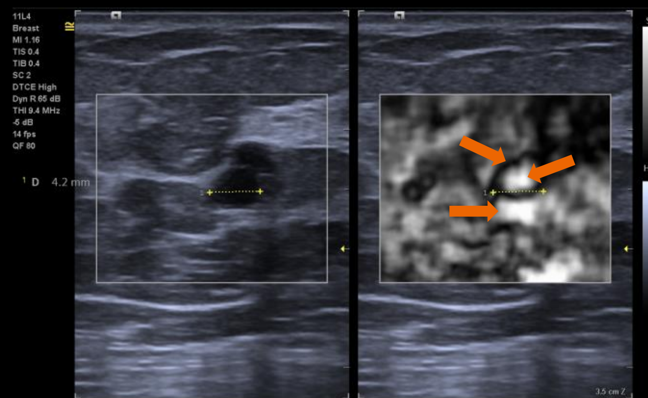
- Dark ring surrounding echogenic center with posterior white spot
- Clinical marker for cysts
- Applies to all organs
- Occurs from decorrelation between images caused by fluid movement in cyst

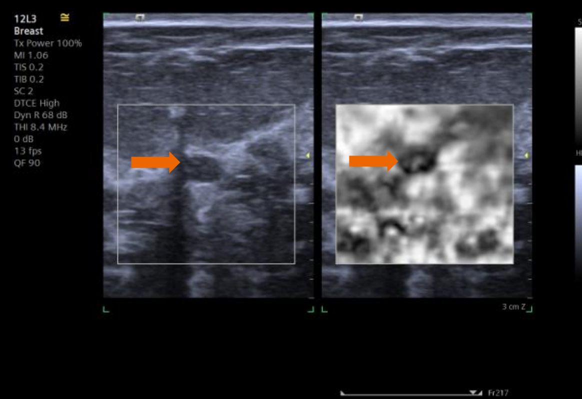


Speaker Notes:

A characteristic of Strain imaging is the “bull’s-eye” appearance in cysts. As shown in this image of a breast cyst, the “bull’s-eye” appears as a dark ring surrounding a bright, echogenic center, with a posterior white spot. It is a useful clinical marker for cysts in any organ imaged with Strain imaging. The bull’s eye occurs from decorrelation between images caused by fluid movement in the cyst.

Solid, complex cyst or complicated cyst

- Lesion with internal echoes on B-mode image
- Solid, complex cyst or complicated cyst
- Bull's-eye appearance on elastogram



Speaker Notes:

Complicated cysts contain low level internal echoes or internal debris which may produce an appearance similar to that of a solid mass or a complex cyst (containing both solid and cystic components). It is important to differentiate a complicated cyst from a complex cyst or a solid mass to best assess lesion management for follow-up, aspiration or biopsy. This slide shows how strain imaging can be used to support the differential diagnosis between a solid mass, a complex cyst or a complicated cyst.

Shadowing

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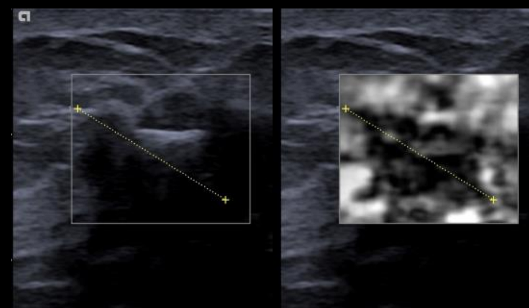
Shadowing displayed on B-mode image

- Difficult to distinguish or measure borders
- of the lesion
- Shadowing does not affect the elastogram
- Borders and size can be more confidently determined



Sonographic properties

Mechanical properties

Speaker Notes:

In this example, the B-mode image displays acoustic shadowing, characterized by the loss of signal around the lateral and posterior borders of a breast lesion due to strong absorption or reflection of the ultrasound waves. Shadowing makes it difficult to distinguish or measure the borders of this lesion. Notice how shadowing does not affect the elastogram. The B-mode image displays the sonographic properties of the image, while the strain image displays the mechanical properties of the image. The borders of the lesion can be identified on the strain image, and the size of the lesion can be determined with greater confidence.

Objectives

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- Explain Virtual Touch technologies
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Speaker Notes:

Lastly, we will demonstrate the point shear wave elastography controls and techniques in the liver application.

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pSWE
Correlation with progression of liver stiffness*

Radiology

REVIEWS AND COMMENTARY • STATEMENTS AND GUIDELINES

Update to the Society of Radiologists in Ultrasound Liver Elastography Consensus Statement

Richard G. Barr, MD, PhD • Stephanie R. Wilson, MD • Deborah Rubens, MD • Guadalupe Garcia-Tsao, MD • Giovanna Ferraioli, MD

From the Department of Radiology, Northeastern Ohio Medical University, Rootstown, Ohio (R.G.B.); Department of Radiology, University of Calgary, Calgary, Canada (S.R.W.); Departments of Imaging Science, Oncology, and Biomedical Engineering, University of Rochester Medical Center, Rochester, NY (D.R.); Section of Digestive Diseases, Department of Medicine, Yale University, New Haven, Conn (G.G.T.); and Ultrasound Unit, Department of Clinical Sciences and Infectious Diseases, Fondazione IRCCS Policlinico San Matteo, University of Pavia, Pavia, Italy (G.F.). Received October 31, 2019; revision requested December 11; revision received April 2, 2020; accepted April 23. **Address correspondence to** R.G.B., Southwoods Imaging, 7623 Market St, Youngstown, OH 44512 (e-mail: *rgbarr525@gmail.com*).

Conflicts of interest are listed at the end of this article.

Radiology 2020; 00:1–12 • https://doi.org/10.1148/radiol.2020192437 • Content codes: GI US

This multidisciplinary update of the Society of Radiologists in Ultrasound consensus statement on liver elastography incorporates the large volume of new information available in the literature since the initial publication. The recommended procedure for acquiring stiffness measurements is reviewed. There has been substantial improvement in the acoustic radiation force impulse (ARFI) technology—most notably the addition of a quality assessment of the shear wave propagation. Due to the efforts of the Quantitative Imaging Biomarkers Alliance, or QIBA, the variability of liver stiffness measurements between systems had decreased. There are now effective treatments for hepatitis B and hepatitis C, and follow-up after effective treatment should be based on the use of the delta change of the value obtained at viral eradication or suppression. Because the detection of compensated advanced chronic liver disease (cACLD) is very important, the new guidelines are made based on the probability of cACLD for given stiffness values. The panel recommends a vendor-neutral rule of four for interpretation for ARFI techniques. This new method simplifies interpretation of liver stiffness results and is more clinically relevant.

*Barr, RG, et al. (2023),"Update to the Society of Radiologists in Ultrasound Liver Elastography Consensus Statement." *Radiology*, 00:1-12. doi.org/10.1148/radiol.2023192437.
https://pubs.rsna.org/doi/10.1148/radiol.2023192437

Speaker Notes:

The gold standard for diagnosing and monitoring the progression of liver fibrosis is liver biopsy. Yet there are known limitations of liver biopsy that make it less than ideal for ongoing assessment of disease progression (e.g., potential complications, availability and costs, intraobserver and interobserver variability and sampling error). The Update to the Society of Radiologists in Ultrasound Liver Elastography Consensus Statement, published in 2023, discusses the correlation between the progression of liver tissue stiffness and shear wave measurements.* Recommended protocols and procedures for acquiring stiffness measurements have been updated to reflect improvements in ARFI technology.

*Barr, RG, et al. (2023),"Update to the Society of Radiologists in Ultrasound Liver Elastography Consensus Statement." *Radiology*, 00:1-12. doi.org/10.1148/radiol.2023192437.
https://pubs.rsna.org/doi/10.1148/radiol.2023192437

pSWE
Correlation with the progression of liver stiffness

The stiffer the tissue, the higher the pSWE measurement

V_S = 0.68 m/s

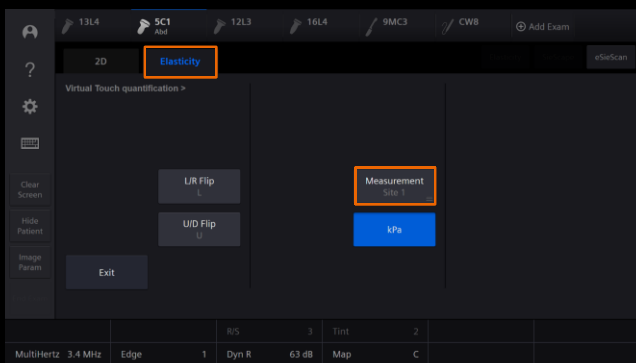
V_S = 1.38 m/s

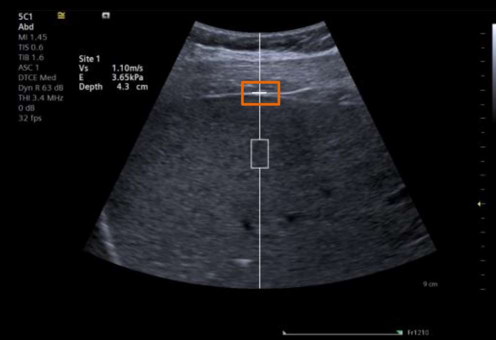
V_S = 1.70 m/s

Speaker Notes:

Liver assessment using gray scale ultrasound findings alone can be difficult. One of the reasons pSWE has become quite useful is the correlation between the progression of liver stiffness with quantitative tissue stiffness values. In the examples shown here, the B-mode image is similar overall, but notice how the shear wave measurements differ. Research reports that shear wave measurements increase proportionally to the degree of liver stiffness.

pSWE controls





Speaker Notes:

pSWE offers a highly reproducible technique using ARFI to correlate liver stiffness with shear wave quantification. To activate pSWE, select the **5C1 or 6C1** transducer and **Abdomen** preset. The pSWE controls will display on the Touch Screen and the ROI will display on the image. Site 1 is the default measurement label. If desired, select an alternate label. If No Label is selected, the measurements will appear next to the image, but will not be sent to the report or added to the overall statistics. Use the reference line to place it on the capsule of the liver. If needed, the trackball can be used to reposition the ROI.

pSWE acquisition

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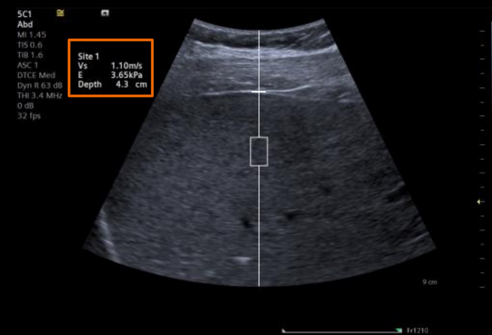

Speaker Notes:

To begin the acquisition, press **Update** on the Control Panel. When the acquisition is complete, the system automatically freezes and displays the shear wave measurement and ROI depth next to the image. To enter the measurement into the report, store the image or press the right or left **Set** key. To make additional measurements, unfreeze the image and repeat the acquisition steps. Press **Report** located on the Control Panel to view, delete, store, print or export shear wave measurements.

pSWE acquisition

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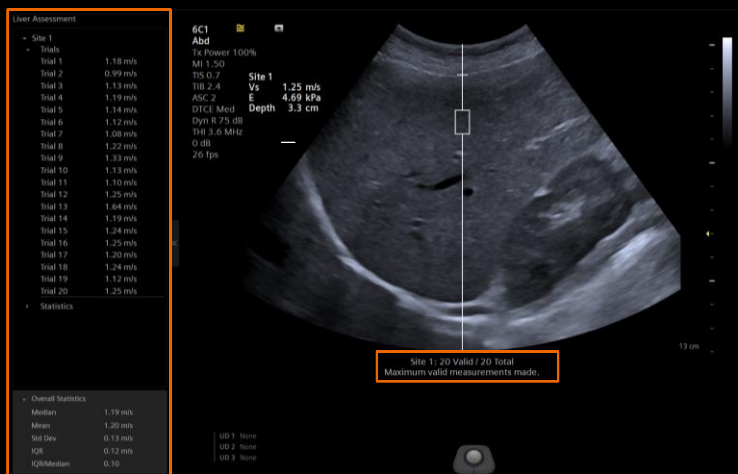

Speaker Notes:

The liver assessment and overall statistics are available on the left side of the image during acquisition. This allows the user to quickly glance at the results without the need for additional keystrokes or exam time to enter the report. A maximum of 20 measurements can be acquired and if exceeded, a message will display “maximum valid measurements made”.

Report measurement unit configuration

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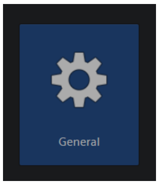
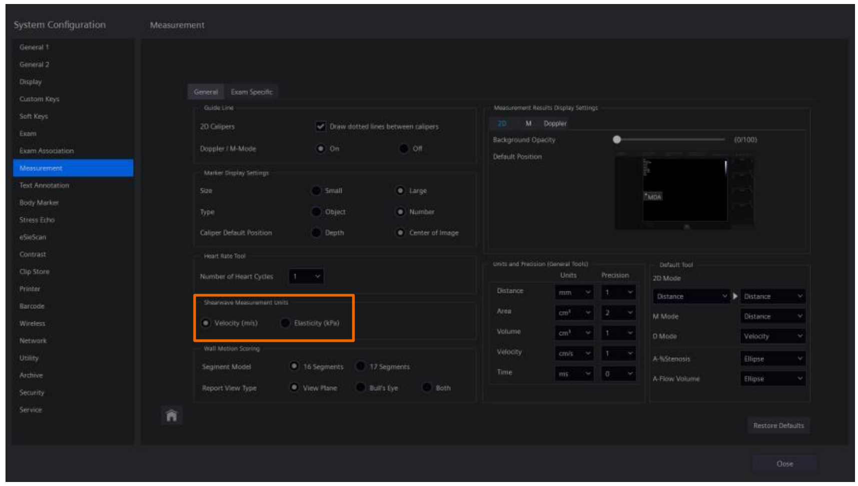
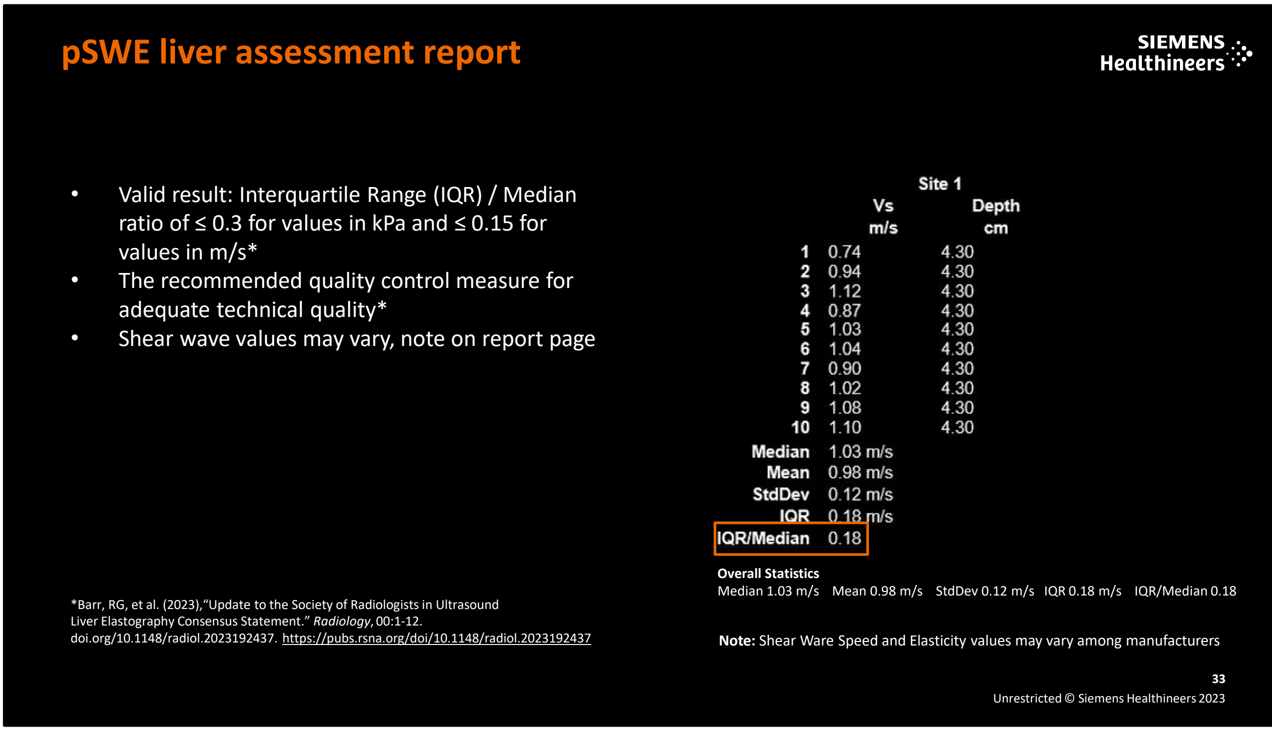




Speaker Notes:

The shear wave measurement unit that is displayed in the report is a global system setting. The default is Velocity (m/s). To customize the shear wave measurement unit displayed in the report, select **System Configuration** > **Measurement & Report** > **Measurement** > **General** > **Shearwave Measurement Unit**. Select either Velocity (m/s) or Elasticity (kPa) for the shear wave measurement unit that will display in the report. Both m/s and kPa will still display next to the image unless hidden from the Touch Screen controls.



Speaker Notes:

Displayed here is the liver assessment report containing each of the measurements along with the statistical data in units of m/s and kPa. It includes the Interquartile Range (IQR), which is the range of the spread of values in a repeated data set, from the 25th to 75th percentile. It is sometimes referred to as the "middle fifty". It removes outlying measurements to more accurately represent the spread of values in a data set. The median shear wave value is used with the IQR to calculate the Interquartile Range to Median (IQR/Median) ratio. An IQR/Median ratio of ≤ 0.3 for values in kPa and ≤ 0.15 for values in m/s indicates that the variability of measurements lies within a reasonable variability range. It is the recommended quality control measure for adequate technical quality. A higher ratio indicates significant variability in the shear wave measurements, decreasing the reliability of measurement results. The IQR will be higher with advancing fibrosis; since the IQR/Median ratio normalizes for this increase, it is an important indicator of technical accuracy.

Note: The IQR/Median ratio for elasticity in units of kPa will be twice the IQR/Median ratio for shear wave velocity in units of m/s as the conversion of m/s to kPa is nonlinear. Absolute values for shear wave measurements may vary among different manufacturers due to multiple system-dependent factors, including shear wave frequency, excitation beam (push beam) frequency, shear wave detection techniques and shear wave measurement estimation methods.

*Barr, RG, et al. (2023),"Update to the Society of Radiologists in Ultrasound Liver Elastography Consensus Statement." *Radiology*, 00:1-12. doi.org/10.1148/radiol.2023192437. https://pubs.rsna.org/doi/10.1148/radiol.2023192437

Best practice techniques
Liver assessment

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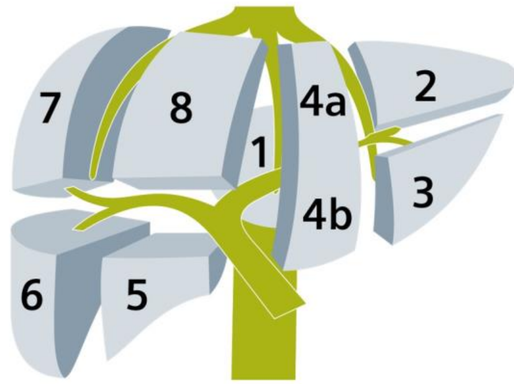
- Fast for at least 4 hours
- Supine or left lateral decubitus, right arm raised
- Use ample gel
- Transducer perpendicular to skin surface, maintain adequate contact
- Intercostal approach, segment 5 or 8



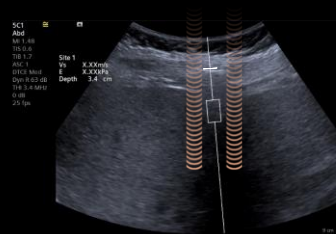
Speaker Notes:

Use best practice techniques when performing point shear wave elastography for reliable and repeatable results. In the non-fasting state, the liver can have falsely increased elastography values; therefore, the recommendation is to have the patient fast for at least 4 hours prior to the exam. Optimal patient positioning is supine or slight 30° left lateral decubitus with the right arm elevated above the head to improve intercostal access. Use ample gel so the transducer surface is in continuous contact with the skin surface. In general, use a transducer angle of 90° to the skin surface for the highest measurement accuracy. An out-of-plane transducer angle of less than 50° to the skin surface can result in artificially low shear wave measurements due to the loss of transducer contact with the flat scanning surface. To obtain reproducible results in the liver and to avoid cardiac motion, take measurements in the right lobe of the liver in either segment 5 or 8, using an intercostal scanning approach.

Best practice techniques
Liver assessment

- ROI between 3-6 cm deep
  (if possible, use default ROI depth for optimum results)
- ROI at least 1.5-2 cm below liver capsule
- Image parallel to ribs with bright liver parenchyma
- Avoid large vessels, bile ducts and rib shadows

Poor pSWE Technique



Better pSWE Technique

Speaker Notes:

Use best practice techniques when placing the measurement ROI for reliable and repeatable results. Maintain a measurement ROI depth between 3 to 6 cm. The default ROI depth best represents the transducer-specific lens focus for that transducer; therefore, the best measurements are in this region. Although the default ROI depth setting for each transducer is the recommended depth, it may need to be repositioned for larger patients. Avoid increased subcapsular reverberation (artifactually induced area of increased stiffness) by placing the ROI perpendicular to and at least 1.5 to 2 cm below the liver capsule. Scan parallel to the ribs in an intercostal space to avoid rib shadow artifacts. Optimize the B-mode image so that the liver parenchyma is bright and large vessels, bile ducts and rib shadows are avoided. As shown here, the image on the left displays poor technique and invalid measurements due to poor propagation of the push pulse through the ribs. In addition, the cursor is angled, and the ROI is too close to the liver capsule. The image on the right displays proper technique and valid measurements.

Best practice techniques
Liver assessment

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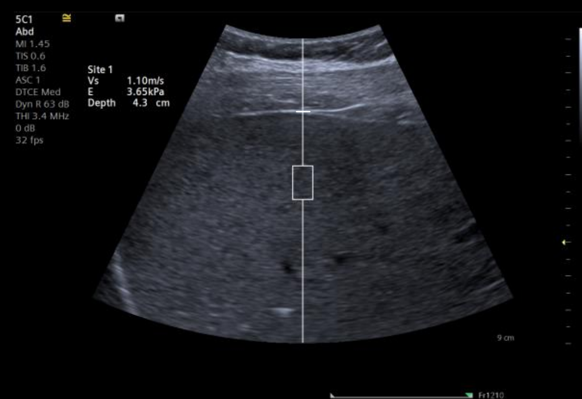
- Perform acquisition during suspended respiration
- Obtain 10 measurements at the same site; fewer can be made (at least 5)*
- Maintain IQR/Median ratio of ≤ 0.3 for values in kPa and ≤ 0.15 for values in m/s*



*Barr, RG, et al. (2023),"Update to the Society of Radiologists in Ultrasound Liver Elastography Consensus Statement." *Radiology*, 00:1-12. doi.org/10.1148/radiol.2023192437.
https://pubs.rsna.org/doi/10.1148/radiol.2023192437

Speaker Notes:

When taking measurements, advise the patient to breathe normally and then to momentarily stop breathing during acquisition. Avoid taking measurements during Valsalva or deep inspiration and breath-hold to avoid an undesired increase in central venous pressure. Elevated central venous pressure can falsely elevate shear wave measurements. When the acquisition is complete, the patient may resume normal breathing. At least 10 measurements should be taken in the same location to aid in measurement repeatability with the median shear wave measurement value representing the most reliable single measure when there are measurement outliers. Fewer than 10 measurements can be made (at least 5); however, the IQR/Median ratio should be within the recommended range. Maintain an IQR/Median ratio of ≤ 0.3 for values in kPa and ≤ 0.15 for values in m/s for adequate technical quality and to ensure that the variability of measurements lies within a reasonable variability range.*

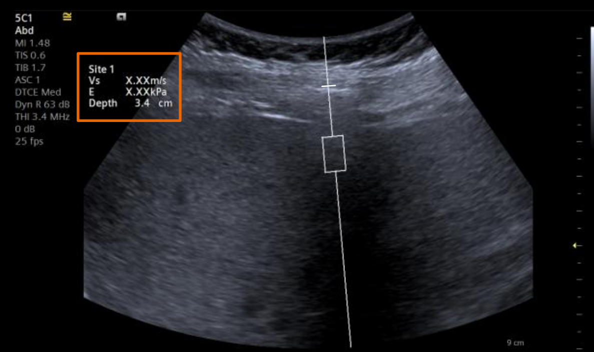
Please note: The IQR/Median ratio for elasticity in units of kPa will be twice the IQR/Median ratio for shear wave velocity in units of m/s as the conversion of m/s to kPa is nonlinear.

*Barr, RG, et al. (2023),"Update to the Society of Radiologists in Ultrasound Liver Elastography Consensus Statement." *Radiology*, 00:1-12. doi.org/10.1148/radiol.2023192437.
https://pubs.rsna.org/doi/10.1148/radiol.2023192437

pSWE measurements
Liver assessment

If X.XX value is displayed:

- Low shear wave signal-to-noise ratio
- Proximity of ROI to the rib shadow (poor technique)
- Measurements exceed the maximum displayable value
- Excessive motion, such as liver tissue movement



Speaker Notes:

If the system displays the shear wave measurement as an invalid “X” value, the confidence interval threshold for measurement quality was not reached. You will need to repeat the acquisition until the system displays a numerical value. Most commonly, this results from a low shear wave signal-to-noise ratio due to either a high tissue stiffness, a large patient body habitus or a thick sono-opaque adipose layer. The push pulse cannot generate enough shear wave magnitude and is grossly attenuated. Invalid “X” values can also be caused by the proximity of the ROI to a rib shadow due to poor technique. It can also display if the measurements exceed the current maximum displayable value. Excessive motion in the tissue that disrupts the shear wave measurement estimate may also produce invalid results.

Patient factors
Liver assessment

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Patient factors can result in an overestimation of liver stiffness

- Liver function – elevated alanine aminotransferase (ALT) or aspartate aminotransferase (AST)
- Underlying disorders or diseases such as obstructive cholestasis, liver congestion, acute hepatitis and infiltrative liver disease

Laboratory findings	Acute hepatocellular damage	Cholestatic jaundice	Chronic alcoholic cirrhosis
Serum total bilirubin	↑↑	↑↑	↑
Serum conjugated bilirubin	↑	↑↑	↑
Serum unconjugated bilirubin	↑	N	↑
ALT	↑↑↑	N/↑	
AST	↑↑	N/↑	↑↑
ALP	↑	↑↑↑	↑
GGT	↑	↑↑↑	↑
Serum albumin	N	N	↓

Speaker Notes:

Patient factors can also result in abnormal shear wave measurement values. These factors should be checked before performing liver stiffness measurements in to avoid overestimation and should be considered when interpreting the results.* Alanine aminotransferase (ALT) levels or aspartate aminotransferase (AST) are blood tests that check for liver damage. When they are significantly elevated above the normal limit, they can indicate liver inflammation as shown here in the table on the right. Underlying disorders or diseases such as obstructive cholestasis, liver congestion, acute hepatitis and infiltrative liver disease can also result in overestimation of liver stiffness. Be aware of the patient's medical history prior to performing a shear wave examination.

*Dietrich, CF, et al. (2017), "EFSUMB Guidelines and Recommendations on the Clinical Use of Liver Ultrasound Elastography, update 2017 (long and short version)." *Ultraschall in Der Medizin - European Journal of Ultrasound,* 38(03), 327-329. doi:10.1055/s-0043-111135. https://www.thieme-connect.de/products/ejournals/pdf/10.1055/s-0043-103955.pdf

pSWE
Rapid, reliable and reproducible

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Comparison of Elastography Modalities

Parameter	TE	pSWE	2D SWE	MR Elastography
Advantages	Point of care for clinician, technique well defined, rapid learning curve, repeatable, presently not recommended for spleen measurements	Can be an independent procedure or an add-on during liver US, direct visualization of liver region being insonated, quantitatively possibly less variability than 2D SWE, can be used to assess the spleen	Can be an add-on during liver US, direct visualization of the liver region being insonated, color display of a larger field of view, can be used to assess the spleen	Closest correlation to adequate liver biopsy, large sample of liver allows for assessment of spatial pattern of disease, no depth dependence of measurement, can be used to assess the spleen, can be performed in patients with obesity or ascites, cross-vendor standardization
Expense	Inexpensive	Inexpensive	Inexpensive	Expensive, unless performed as a limited MR elastography–only examination
Frequency for shear wave generation	40–50 Hz ("S," "M," "XL" probe dependent)	100–500 Hz	100–500 Hz	60-Hz standard, other frequencies possible.
Limitations	Needs dedicated machine, probe needs recalibration every 6–12 months depending on probe, failures due to ascites and obesity (obesity failures may be overcome with the use of extra-large probe), no grayscale image of liver (A-mode images are available), lower performance compared with ARFI techniques (36,55,56,57)	Less published material than TE owing to shorter time in use	Less published material than TE owing to shorter time in use	Failures due to iron overload (newer sequences will reduce these), failures due to claustrophobia, not as widely available as TE, higher charges for examination
Measurement location	Right intercostal space (dullest area of percussion)	Most often segment VII or VIII	Most often segment VII or VIII	Right lobe of the liver in four sections
Region of interest (ROI) size	About 4 cm^3	About 0.5–1.0 cm^3	About 20 cm^3	About 250 cm^3
Value reported	Median of 10 measurements, check IQR/median value < 0.3	Median of 10 measurements*, check IQR/median value < 0.3 if the stiffness value is > 1.5 m/sec (7.1 kPa)	Median of 10 measurements*, check IQR/median value < 0.3 if the stiffness value is > 1.5 m/sec (7.1 kPa)	Mean or median of ROI measurements in four sections
Defining a good measurement	Machine does not report value if inadequate	Not "x.xx" or "0.00"	ROI area not colored	Confidence map shows areas that are above a threshold

*Each vendor has a recommended number of acquisitions. The listed number is the consensus recommendation.

pSWE

Can be an independent procedure or an add-on during liver US, direct visualization of liver region being insonated, quantitatively possibly less variability than 2D SWE, can be used to assess the spleen

*Barr RG, Ferraioli G, Palmeri ML, et al. Elastography Assessment of Liver Fibrosis: Society of Radiologists in Ultrasound Consensus Conference Statement. *Radiology*. 2015;276(3):845-861. doi:10.1148/radiol.2015150619.

Speaker Notes:

Studies have shown pSWE to be rapid, reliable and reproducible in the measurement of shear waves in the liver. As a software option on the ACUSON Juniper system, it is easy and convenient to use in conjunction with a standard abdominal ultrasound exam. As shown here, the Society of Radiologists in Ultrasound “Consensus Statement” also discusses the possible advantages of point shear wave elastography when compared with 2D SWE during elastography assessment of liver fibrosis.

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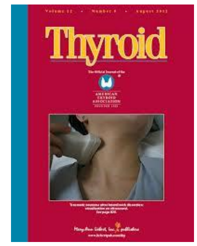
Siemens Healthineers Virtual Touch technologies
Clinical evidence

- Siemens Healthineers is the first company to have ARFI-based technologies
- Worldwide adoption since 2008
- Several hundred papers
- Multiple specialties
- Nearly 1000 sites worldwide



JOURNAL OF HEPATOLOGY

Speaker Notes:

When you expand your clinical offering with a critical new technology such as elastography, it is important to choose a partner that has industry leading advanced elastography solutions with strong clinical validation so that you can be confident of its adoption into personalized clinical pathways. Siemens Healthineers provides this partnership with confidence leading the way with over 400 publications since the introduction of elastography in 2008. We encourage you to investigate and discover for yourself the clinical validity of our technology at the third-party research database at www.mendeley.com.

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Speaker Notes:

No speaker notes.

Thank you for your enthusiasm!

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Questions?

Speaker Notes:

No speaker notes.